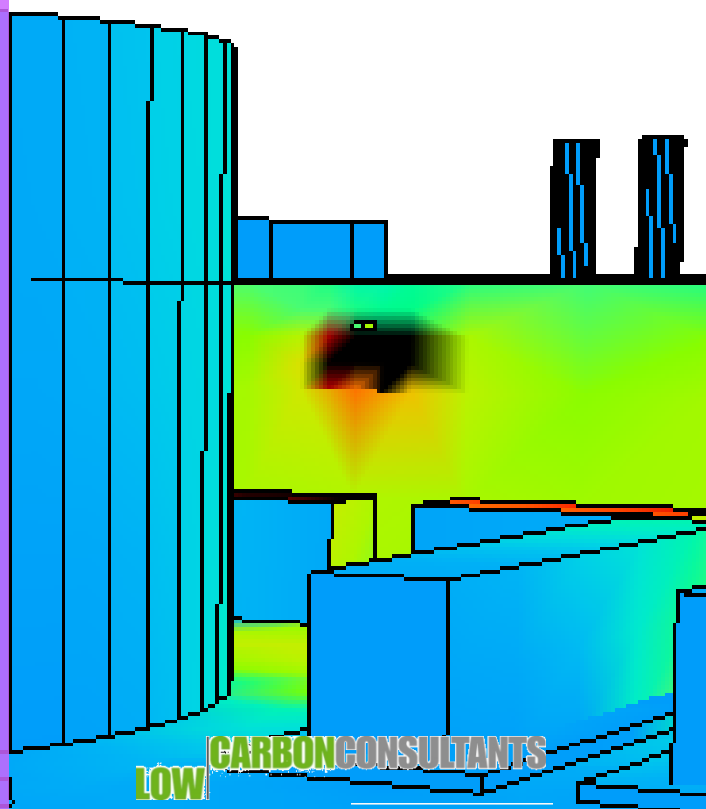


IMPACT ASSESSMENT ON THE EXTERNAL LIGHTING INSTALLATION AT FIVE FORDS, WREXHAM

Project N°: 4529
Revision: P5
Date: March 2021
Client: Low Carbon Farming 2

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DOCUMENT REVISION SHEET

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GLOSSARY OF TERMS

Term	Meaning/Definition
A	Ampere
AD	Approved Document (of the Building Regulations)
BT	British Telecom
CDM	Construction Design and Management Regulations
CIBSE	Chartered Institute of Building Services Engineers
DX	Direct expansion
DP	Distribution Point
EAWR	Electricity at Work Regulations
kA	kilo Ampere
kV	kilo Volt
kW	kilo Watt
mV	milli Volt
IET	Institute of Engineering Technology (Formerly Known as the IEE Institute of Electrical Engineering)
IP	Ingress Protection
ISO/BS/EN	International Organisation for Standardisation / British Standard / European Norm
m ³ /hr	Meters cubed per hour
mA	milli Ampere
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MDPE	Medium-density polyethylene
OHP	Overhead and Profit
PIR	Passive Infra-Red
RCD	Residual Current Device
RCBO	Residual Current Circuit Breaker with Overload Protection
SPN	Single Phase and Neutral
TPN	Three Phase and Neutral
UPS	Uninterruptible Power Supply
UV	Ultraviolet
V	Volt
W	Watt

1 INTRODUCTION

Pope Consulting Ltd have been appointed by Low Carbon Farming 2 Limited to assess the impact that a limited external lighting installation that is associated with the new building structure(s) (primarily the car parking areas) will have on the surrounding environment. It should be noted that the internal lighting is not being considered as it will not make a significant contribution to the lighting as it will be mitigated by the use of blinds.

It should be noted that the proposed lighting strategy herein is indicative only and further detail will be provided via discharge of a planning condition.

2 REQUIREMENTS FOR THE LIGHTING INSTALLATION

All proposed lighting arrangements should comply with the guidance set out in the CIE 150 (2017) Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, 2nd Edition.

This lighting report will demonstrate how the light arising from the site will comply with Environmental Zone E2 in Table 1 of the above guide. More detailed explanation of what this entails can be found later in the body of the report.

In addition, this area is known to have bats in the vicinity so measures must be taken to mitigate the impact of the lighting on the bat's feeding habits and their commuting routes.

The ecologist employed for this project has advised that

- The lighting should follow guidance from the Bat Conservation Trust and CIE 150:2003 (e.g. warm-white (long wavelength) lights with UV filters fitted as close to the ground as possible. Lighting units to be angled below 70° and equipped with movement sensors, baffles, hoods, louvres and horizontal cut off units at 90°.)
- Lighting should only be used where absolutely necessary and using the minimum amount of luminance required.
- No lighting should be situated along the site periphery or linear features that may be used by bats (e.g. hedgerows, treelines, woodland edges, etc.)

Reference will therefore be made to the guidance within the Bat Conservation Trust's Designing for Biodiversity (2017), 2nd Edition.

3 EXECUTIVE SUMMARY

The design for this installation is compliant with Environmental Zone E2 of Table of CIE 150 (2017) Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, 2nd Edition.

The installation can therefore also be said to be as aligned with the guidance contained within the Bat Conservation Trust's Designing for Biodiversity (2017),

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2nd Edition as possible, whilst still maintaining a low level of safety lighting to the area.

The lighting installation can further be said to mitigate the light falling outside the areas being illuminated to levels low enough to be satisfactory

With reference to CIBSE guidance and BSEN 12464 Part 2 the installation does not comply as the overall lux level is too low as is the uniformity. This means the average lux levels are below the minimum levels considered adequate for safe working in the outdoor environment.

It would be advisable to ensure all vehicles only undertake movements with headlights on and it would be prudent to ensure that any large vehicles utilise a banksman or similar for safety.

However, the intention for this installation is that a low level of light is provided purely for safety and higher levels would impact negatively on the surrounding environment.

The expected hours of illumination for external lighting will be as follows:

Summer (April – December) 20:30 – 22:00

Winter (December to April) 06:00 - 09:00 and 16:00 – 22:00

4 LIGHTING

4.1 GENERAL

The specifics of the installations have not yet been designed, but, in the absence of this information, the following have been assumed, based on other similar facilities:

- The luminaires are to be of good quality and high efficiency.
- The luminaires are to be complete with an LED source to promote energy conservation and efficiency.
- The luminaires will be complete with an LED source to eliminate the production of UV frequencies in adherence to the guidelines made within the Bat Conservation Trust's Designing for Biodiversity (2017), 2nd Edition.
- Light sources will be 3000°K rather than the more normal 4000°K in adherence to the guidelines made within the Bat Conservancy Trust's Designing for Biodiversity (2017), 2nd Edition.

Car Park luminaires will be wall mounted or bollard mounted, with wall mounted fittings assumed to be at circa 7m to lantern. It can be demonstrably quantified that the use of lighting equipment mounted closer to the ground will be detrimental to the overall scheme because more lighting units will be required, the overall quantity of emitted light will be increased and the lighting units will need to be angled up from horizontal to achieve the light distribution – all of which are contra-indicated in the CIE 150 (2017) Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, 2nd Edition guide.

Basic lighting controls will be utilised, in adherence to the guidelines made within the Bat Conservation Trust's Designing for Biodiversity (2017), 2nd Edition.

The exterior luminaires have been modelled to provide an adequate level of car park illumination to assist pedestrians to safely walk around and to/from the car park area only.

Any additional lighting to loading bays and other items of main plant (CO2 tanks for example) that have lighting adjacent have not been considered as this lighting will be used for maintenance or specific functions only and not left on for extended periods of time.

All the fittings considered have been photometrically tested and the photometric data provided and installed into lighting design software (as detailed below).

For the purposes of this report, the external emergency lighting has not been considered.

It is understood that the Glasshouse will be complete with automatic blackout/light pollution controlling blinds interconnected with a Horticultural Management System [HMS] which will obviously restrict the light that would otherwise have spilled out from the glasshouse.

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Currently, the specific system and blinds have not been selected, but it is understood that the typical blackout blinds for such commercial glasshouses would offer the following benefits:

- Reduced energy requirements if an aluminium/reflective top layer is employed
- Ultra-low light pollution emission rates of less than 0.5%

See below extracts:

“Light pollution screens are often used in a combination of horizontal and vertical screening, especially when growing crops using supplementary lighting. Greenhouse owners must meet increasing regulatory obligations on light emission- light pollution screens ensure minimal light emission and depending on the type of screen cloth, emission rates of less than 0.5% are achievable.

Through the use of light pollution screens, the light intensity of the supplementary lighting can be retained within the greenhouse. Furthermore, the light pollution screens, open structure, in combination with good ventilation, helps control moisture and warmth.”

And also the following:

“With a light reduction level of over 99.9%, blackout screens are very suitable for light sensitive crops and short-day plants such as chrysanthemums. Additionally, by choosing a blackout screen with an aluminium top layer, energy savings can go up to 75%.”

Cambridge HOK website ©2021 Cambridge HOK

A notional blackout and light pollution product recommended by Cambridge HOK is the Svensson Obscura 9950 FR W – See Appendices for data sheet.

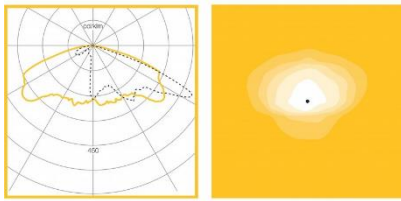
See Appendices for additional controls and materials descriptions as provided by Cambridge HOK

Growing lights and/or other lights designed to provide anything other than emergency lighting shall not be operated within the glasshouses in darkness hours except at times when blackout blinds are fully employed. This will be ensured by the use of the Horticultural Management System and therefore the glasshouse lighting has not been considered as part of this report as it will comply with the requirements of the environmental zone restrictions.

4.2 WALL MOUNTED LUMINAIRES

The wall mounted luminaires are Whitecroft Lighting’s Levanter Range of lanterns. This luminaire has been selected due to the wide and directional distribution, relatively low output level and it has an Upward Light Output Ratio [ULOR] of 0.0%, as can be seen from the Luminosity Distribution Curve (LDC) below. Note that the fittings would be required to be provided with the wall mounted fixing.

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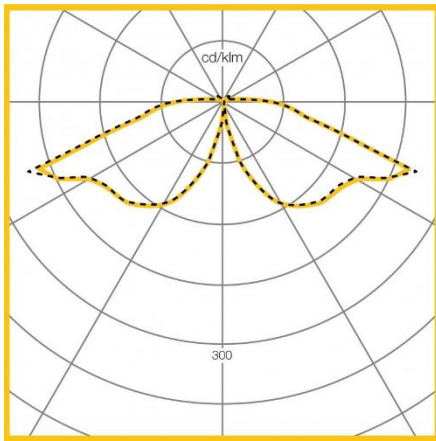
Effective luminous flux
Specific luminaire luminous flux

5725 lumens
82.7 lumens/Watt



4.3 FLOOR MOUNTED BOLLARD LUMINAIRES

The floor mounted bollard luminaires near/at the car parking areas are Whitecroft Lighting's Kolo range of bollards. This luminaire has been selected due to the wide and directional distribution, relatively low output level and it has an Upward Light Output Ratio [ULOR] of 0.0%, as can be seen from the Luminosity Distribution Curve (LDC) below.



Luminaire luminous flux*:1425 lumens
Luminaire efficacy*:109.62 lumens/Watt



4.4 LIGHTING CONTROLS

A system of robust, simple lighting controls will be utilised to provide basic control of the operation of the night-time lighting, generally using timeclock/photocell based activation of the lighting. The lighting will therefore be set out as below:

- A photocell will be provided wall mounted at high level on a North facing wall. This will detect the natural light levels and prohibit the lights from being energised when there is sufficient natural light.
- The circuits will each be connected through a timeclock that will further restrict the hours of operation to pre-set times only.
- When the photocell detects a low enough level of natural light and this falls within the permitted times as dictated by the timeclock, then the lights will be energised.

5 CALCULATIONS

A 3D model has been generated in Relux Desktop Lighting Design Software
<http://relux.com/en/>

The most current version of the programme has been utilised, version 2020.2.6.0

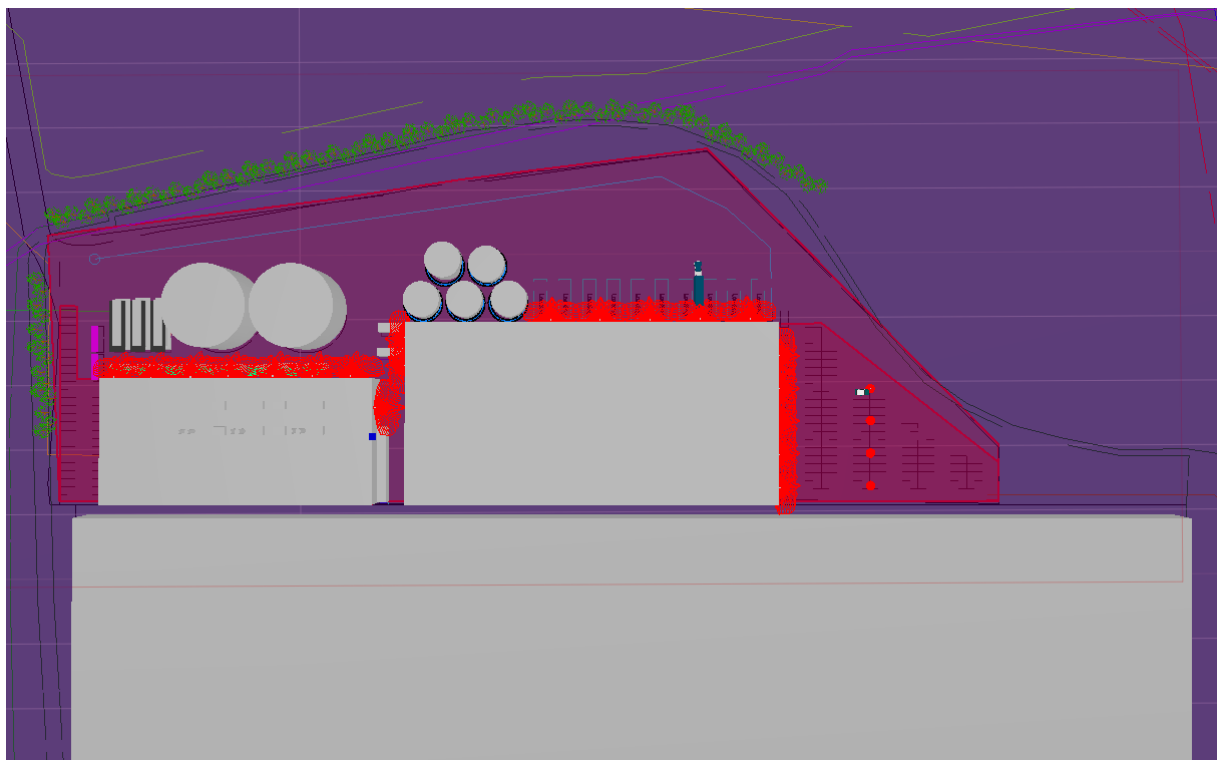
The model incorporated simple solid cuboid elements to represent the various structures as there is no need to provide any architectural details.

All luminaires were modelled as being 'on' with an output of 100%.

Within the model, several measuring planes have been applied. There is one for each car park (East and West) and one for the hardstanding area as a whole. In addition, there is a further larger measuring plane that has been placed above the hardstanding area (circa 12m above the ground) and inverted. In this way, the light escaping above the installation can be measured also.

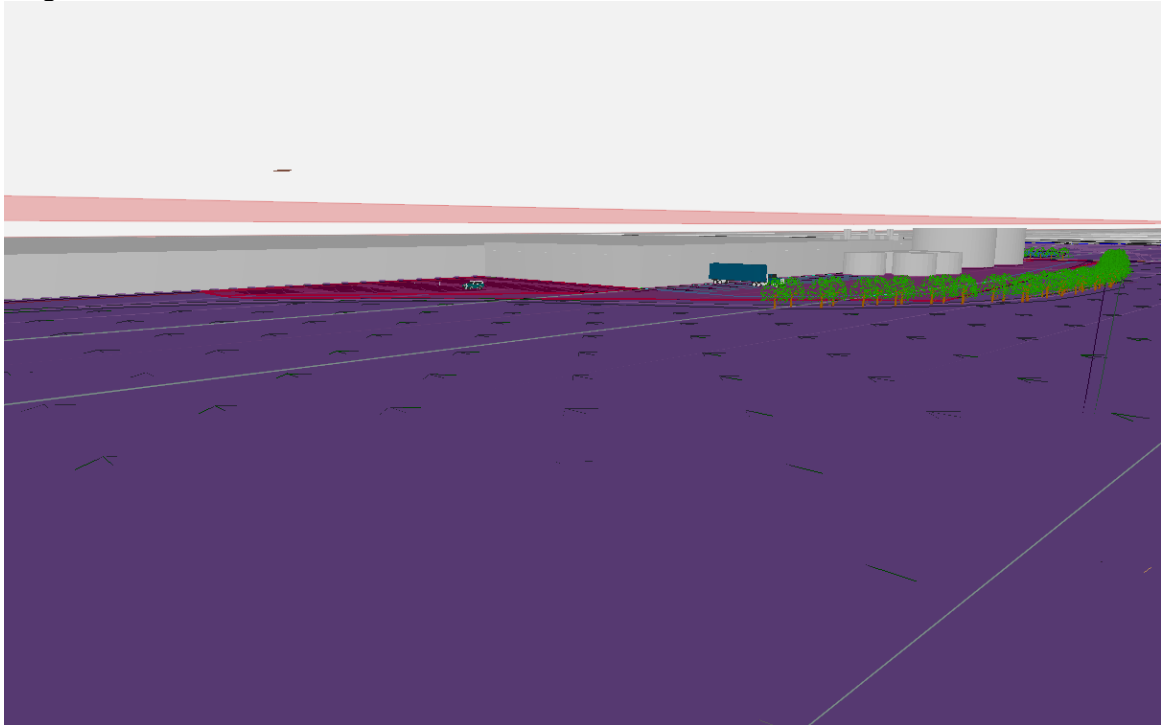
This is the model from above showing the main area of interest. The model ground level is shown by the purple layer, and the measuring planes are the red shapes on top of the purple layer. The model is drawn to scale, based on the CAD drawing file. In one of the loading bays at the top of the packaging building is an articulated lorry and in the car park on the Right Hand Side (Car Park East) there is a standard SUV type car. Both added for scale. The car is the small whiteish rectangle at this height. Standard tree models have been used to represent the proposed new lines of trees to the North and West

The software utilises a standard radiosity algorithm in undertaking the calculations. The radiosity algorithm determines the external lux level calculations from the luminaires.

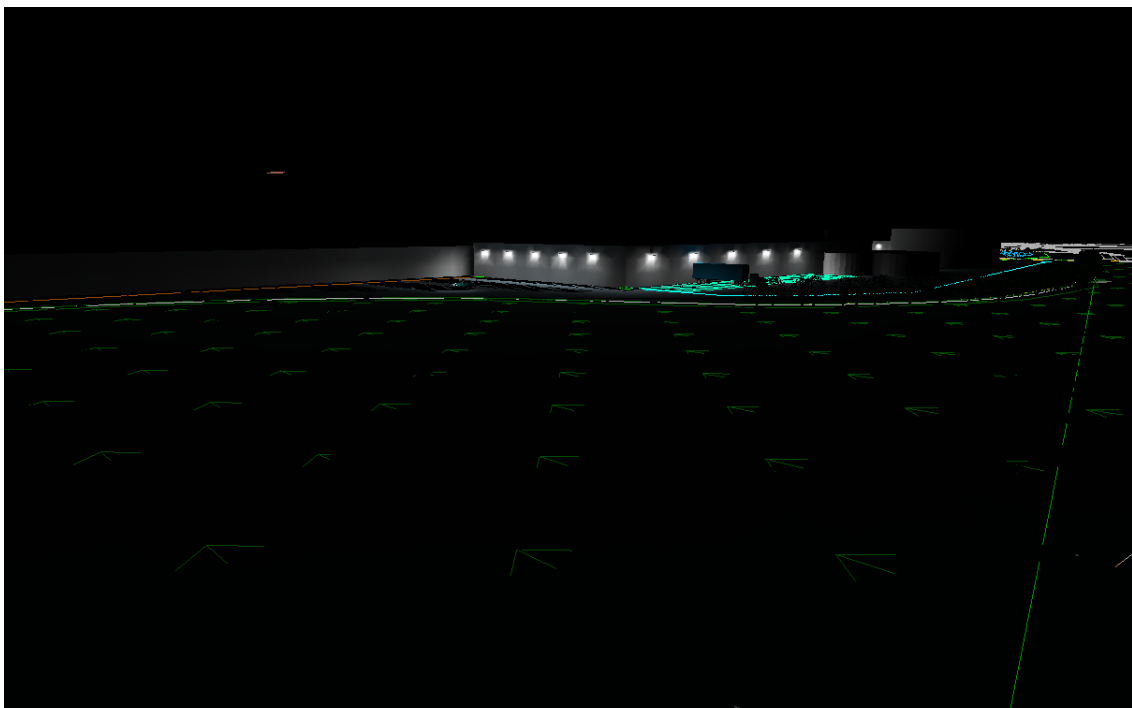


5.1 CAR PARK EAST

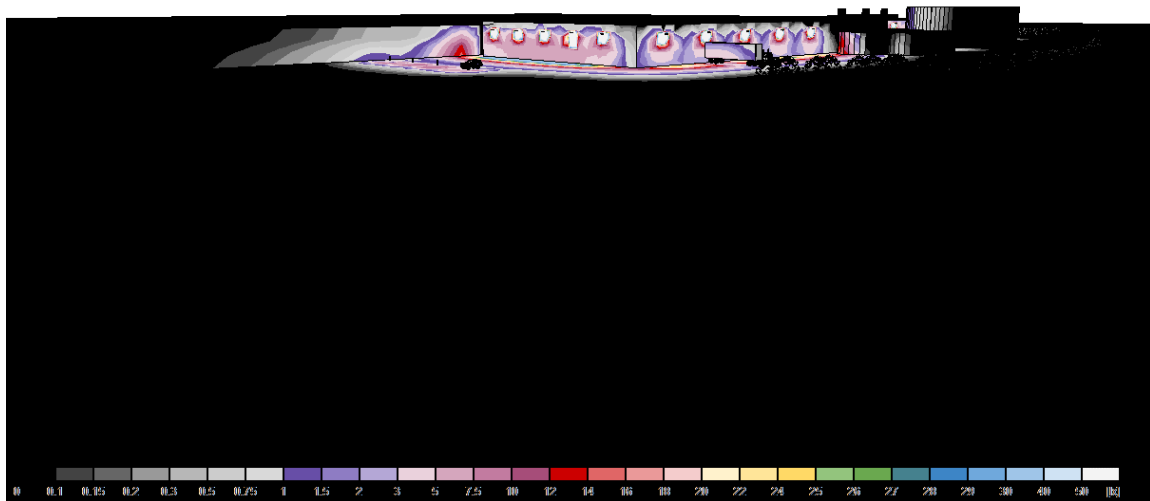
The image below shows the view from the North East with the processing block in the middle of the picture, the energy centre on the right and behind the closest greenhouse. The purple floor area can be seen and the red measuring planes are visible also. Above the facility, the inverted measuring plane can be seen from this angle.



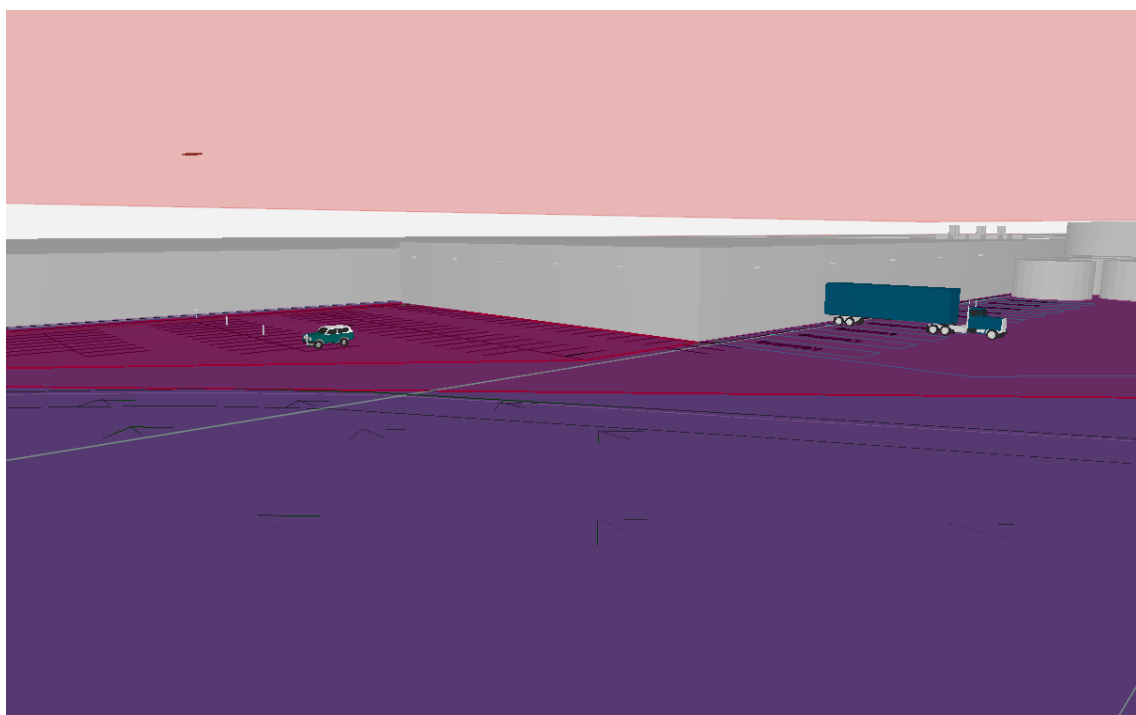
This is the same image as above, but with the calculation results indicated. Note that although the areas of light appear bright – it is because of the lack of light throughout the rest of the site making the areas appear bright against a dark background.



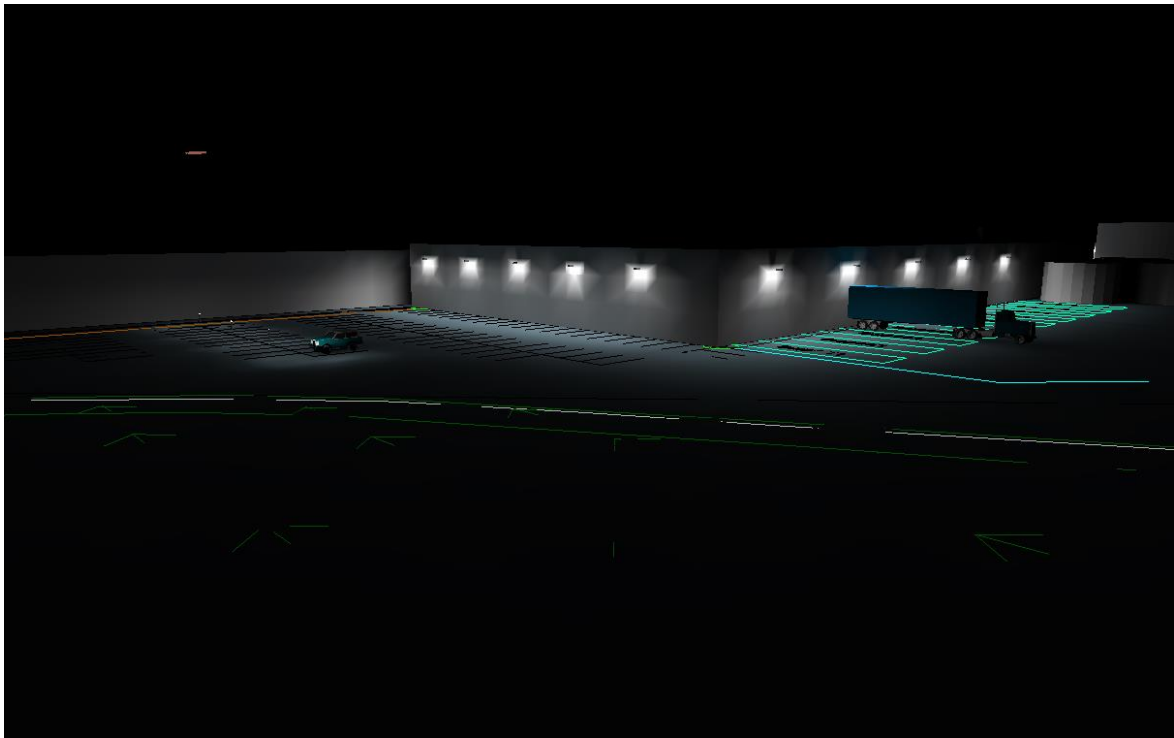
The further rendering below is the same image again, but this time the different light levels have been assigned a colour to represent the intensity – sort of akin to a heat map where the darker (grey and black) end of the colour spectrum represents little light and the other colours from the colder (blue) to the hotter (red) end of the spectrum representing the lux levels increasing. It should be noted that this represents a relative increase in light, from black to red as shown on the lux level legend at the bottom of the image.



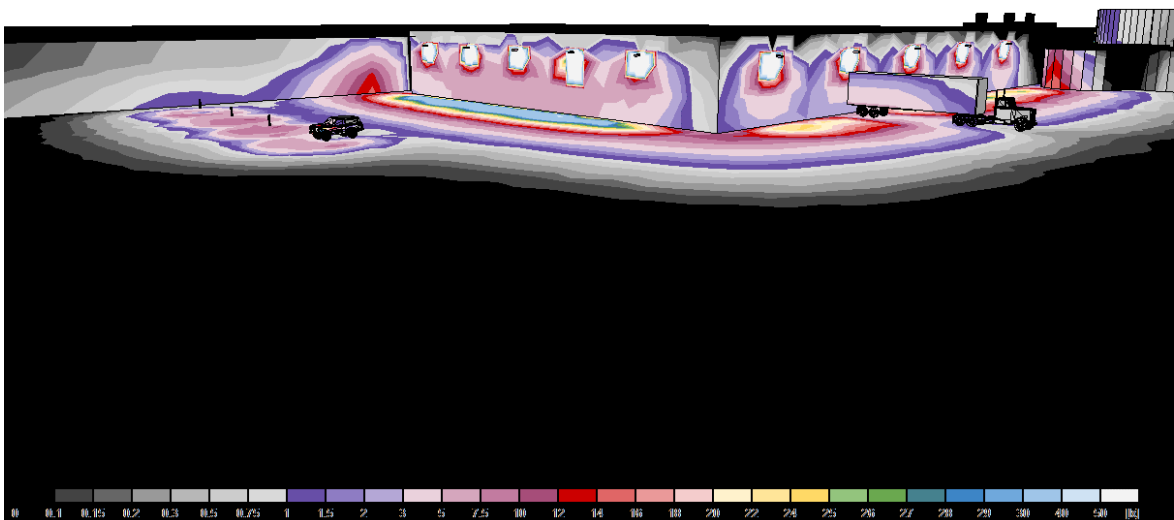
For clarity, the image below is a closer view of the same image now focussing on the car parking area (and now the SUV model can be more easily discerned) as this is the area where the night-time lighting will be utilised.



The image below shows the calculation outputs again.



The image below again shows the same scene, but with the calculation results as a heat map of lighting levels for greater clarity

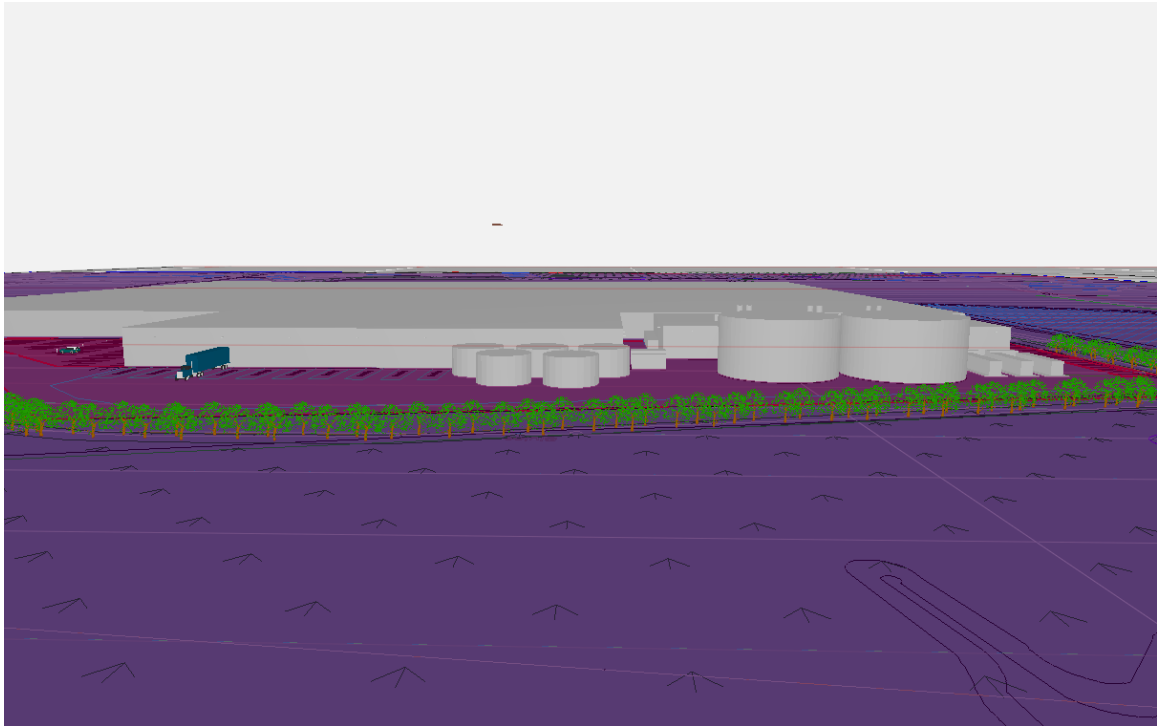


Below is the layout of the Car Park – showing the lighting distribution curves emanating from each luminaire. The wide wing type distribution is from the street lighting lanterns fixed to the walls and the smaller distributions are from the ground mounted bollards. It can be seen that the car park is not overlit and the light has minimal spillage outside this area.

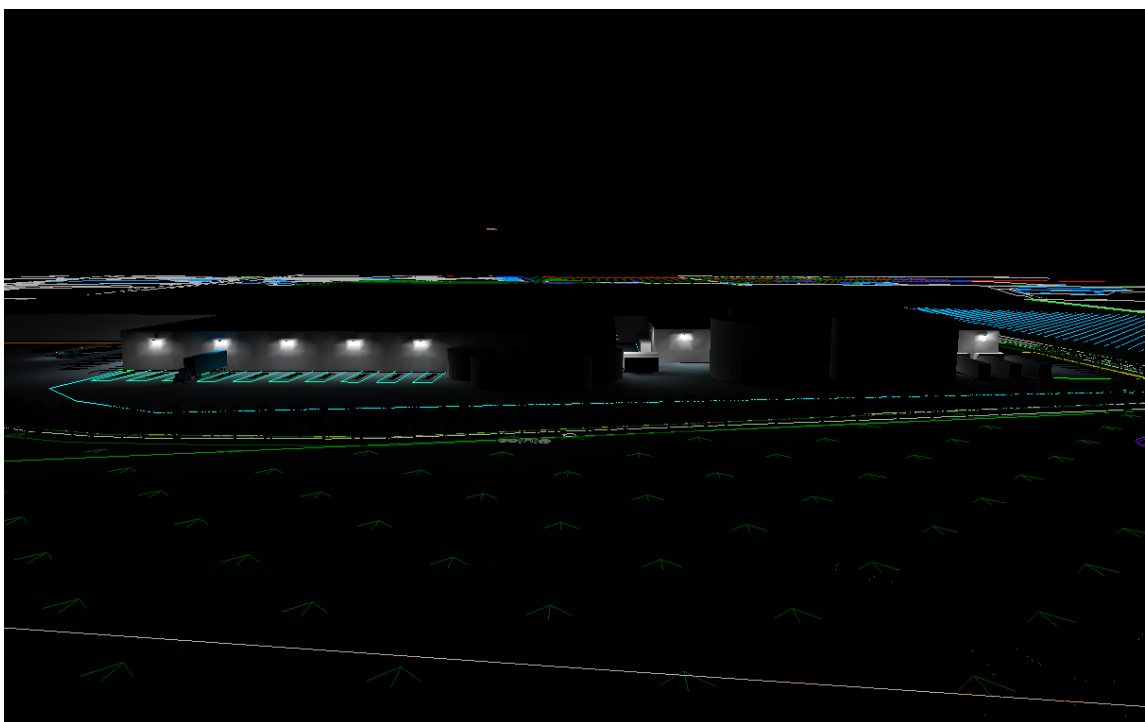
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5.2 MAIN HARDSTANDING

The image below shows the view from the North with the processing block to the left of the picture, the energy centre in the middle and the left and also on the left is the West Car Park. The purple floor area can be seen and the red measuring planes are visible also. This time, the inverted measuring plane cannot be seen from this angle.



This is the same image as above, but with the calculation results indicated. Note that although the areas of light appear bright – it is because of the lack of light throughout the rest of the site making the areas appear bright against a dark background.

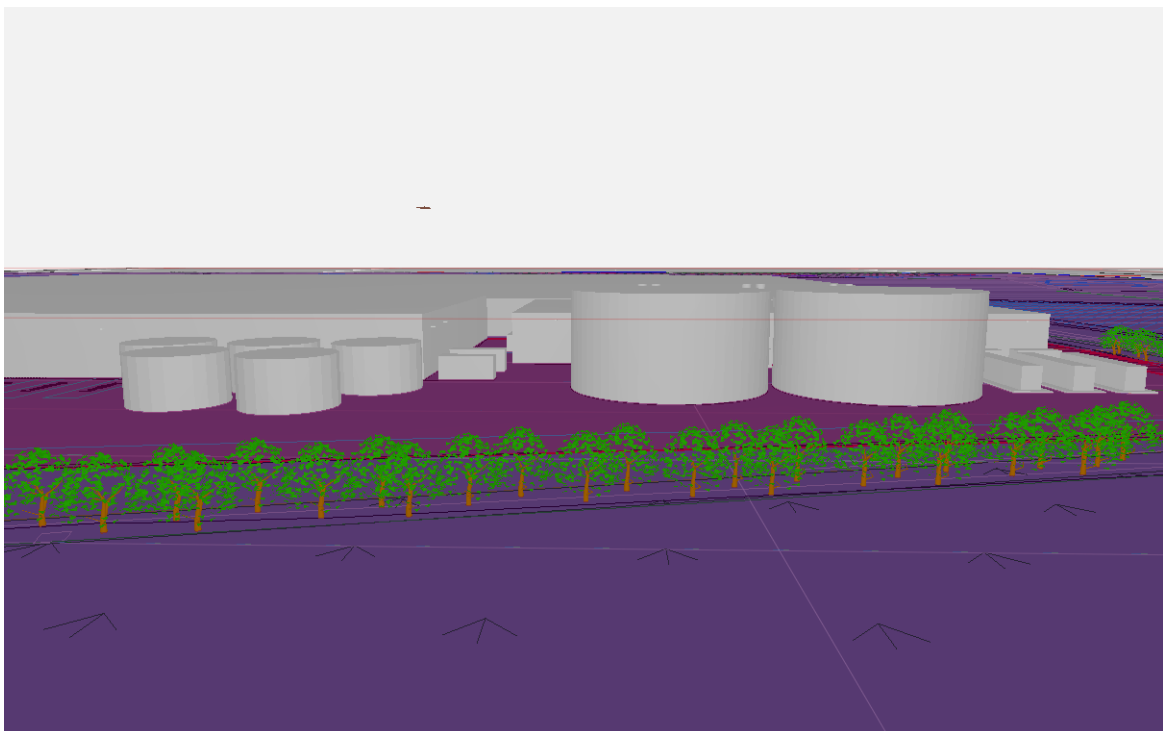


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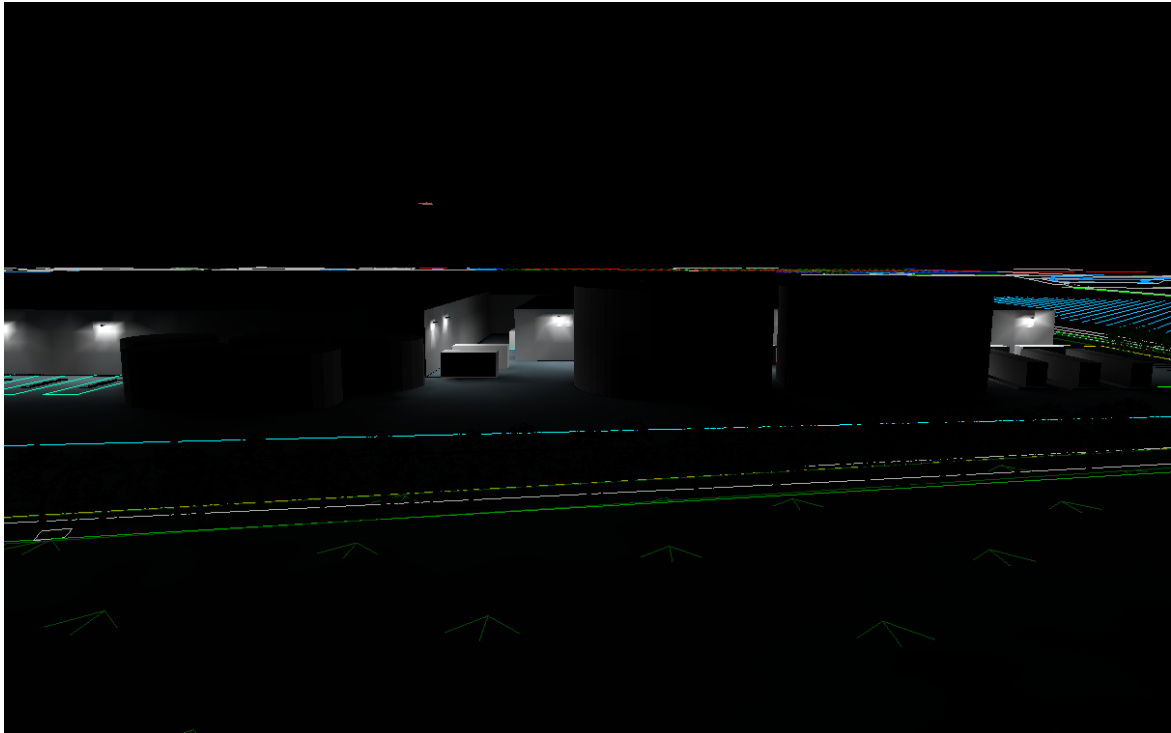
The further rendering below is the same image again, but this time the different light levels have been assigned a colour to represent the intensity – sort of akin to a heat map where the darker (grey and black) end of the colour spectrum represents little light and the other colours from the colder (blue) to the hotter (red) end of the spectrum representing the lux levels increasing. It should be noted that this represents a relative increase in light, from black to red as shown on the lux level legend at the bottom of the image.



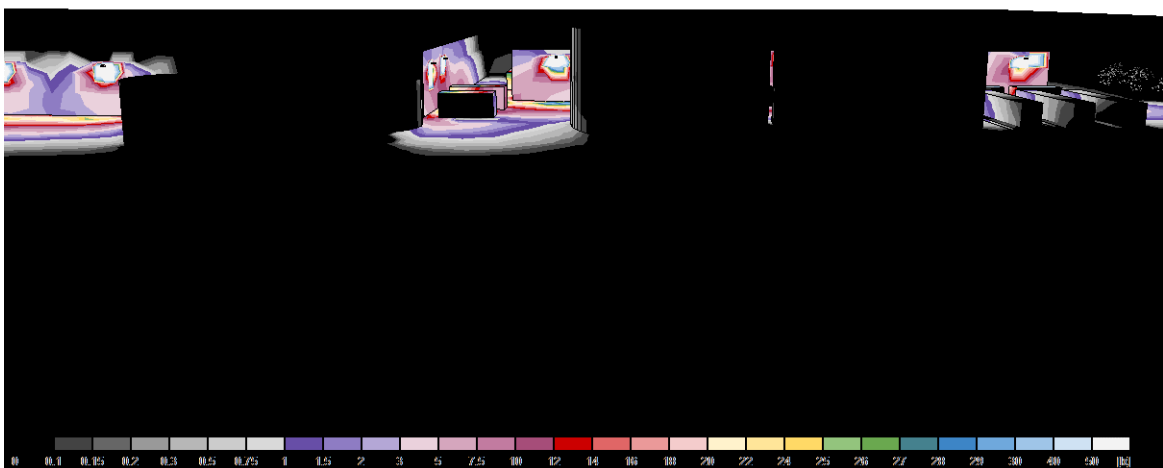
For clarity, the image below is a closer view of the same image now focussing on the main energy centre and packaging areas as this is the area where the night-time lighting will be utilised.



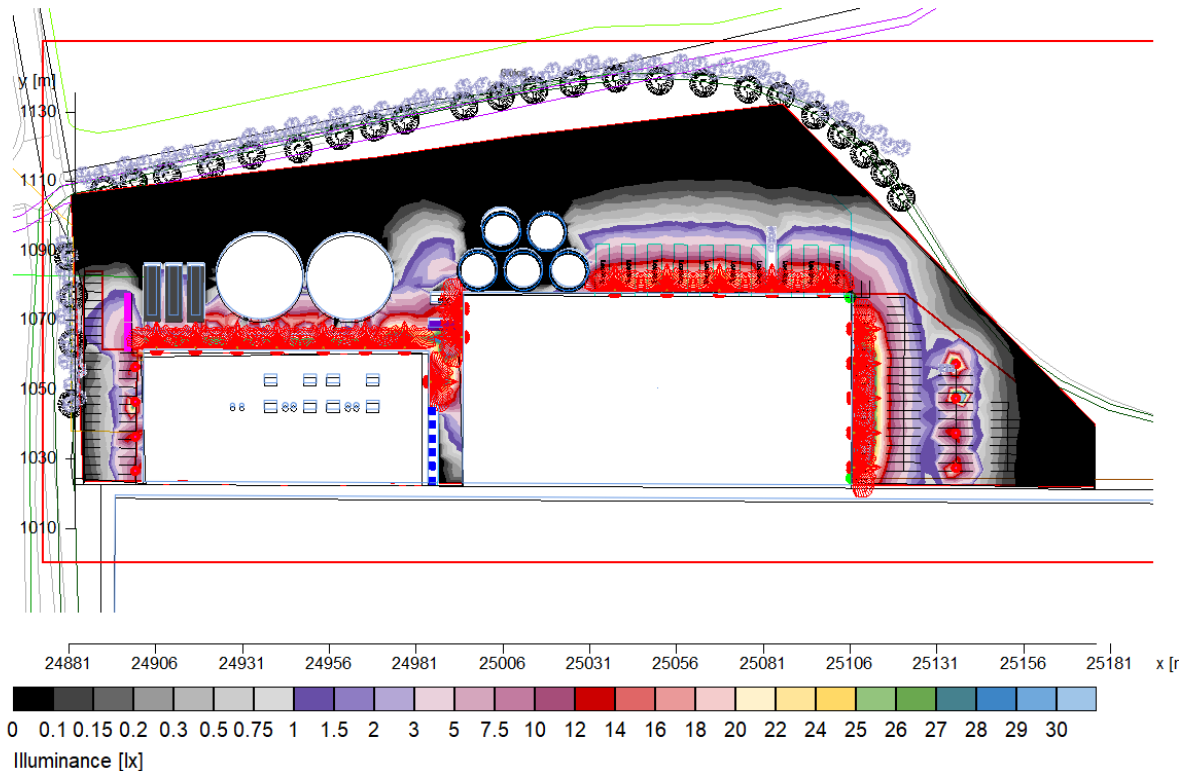
The image below shows the calculation outputs again.



The image below again shows the same scene, but with the calculation results as a heat map of lighting levels for greater clarity



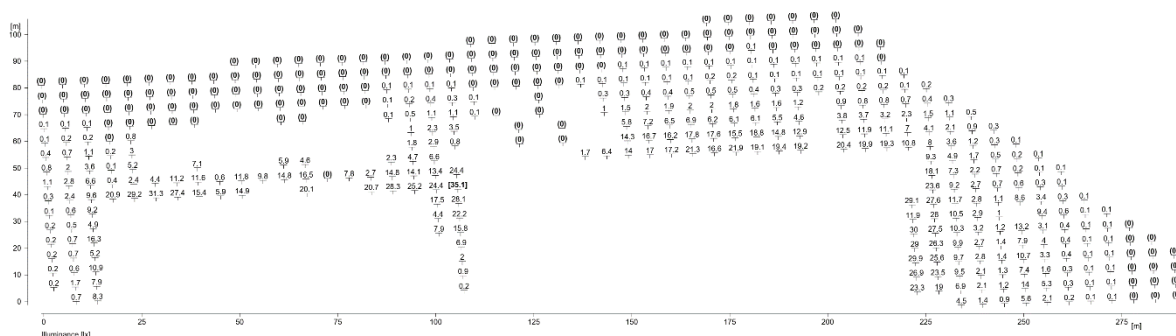
Below is the layout of the hardstanding - showing the lighting distribution curves emanating from each luminaire. The wide wing type distribution is from the street lighting lanterns fixed to the walls and the smaller distributions are from the ground mounted bollards. It can be seen that the hardstanding areas are not overlit and the light has minimal spillage outside this area.



The calculation results for the Hardstanding are as follows:

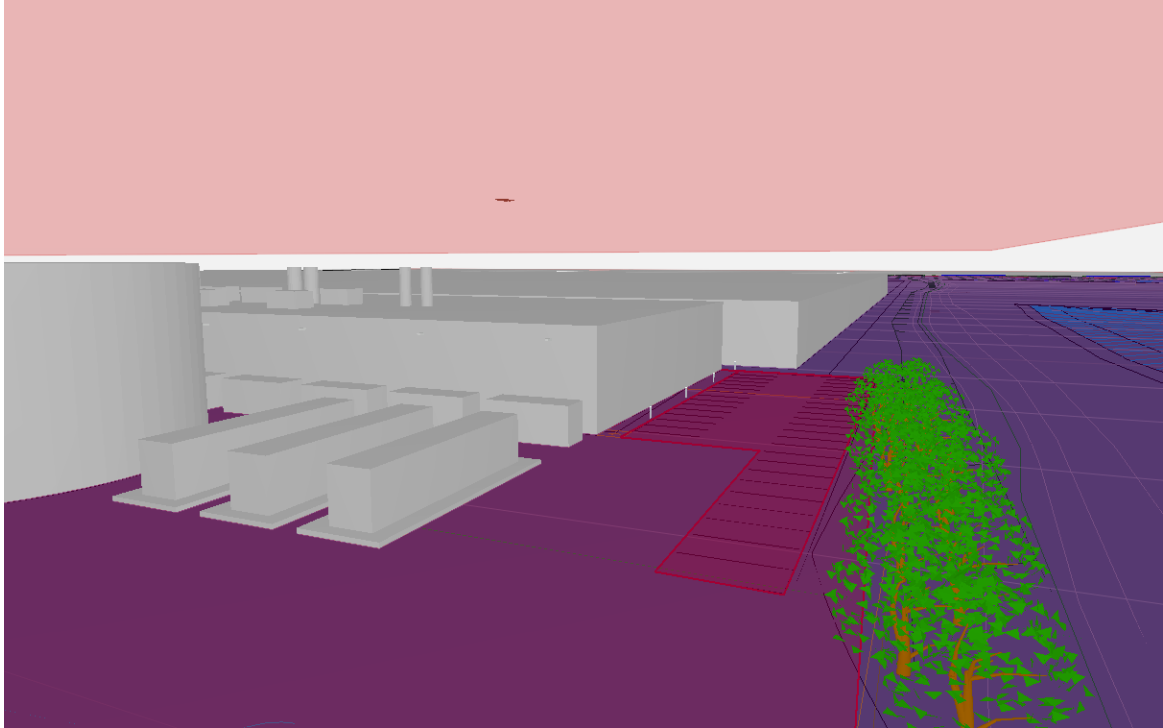
Average illuminance 4.1 lux
Minimum illuminance 0.0 lux
Maximum illuminance 35.1 lux
Uniformity 0.0

And below is the table of results showing the specific lux levels at each point of calculation for the Hardstanding:



5.3 CAR PARK WEST

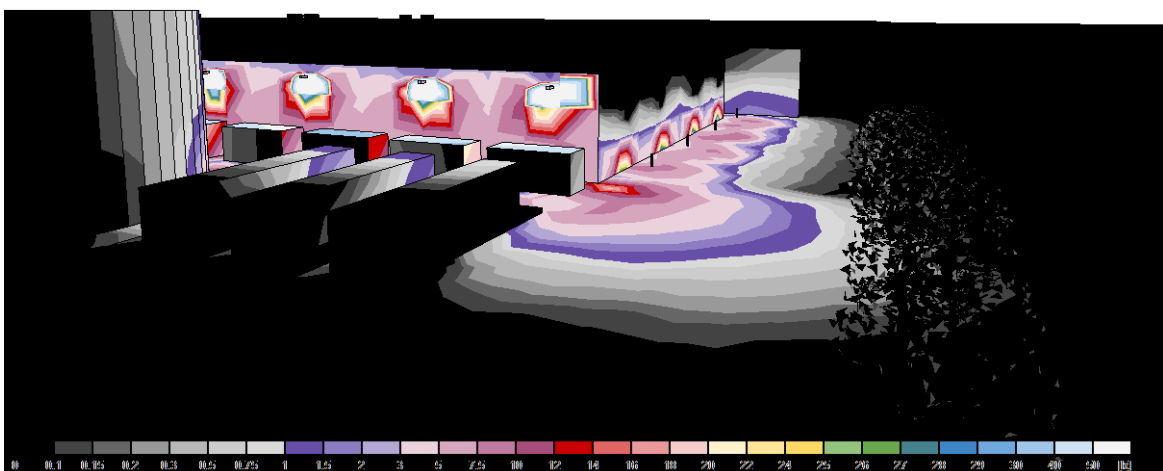
The image below shows the view from the North West with the greenhouse to the right of the picture, the CO₂ storage tanks on the left and the energy centre in the middle with the car park area in front of it. of the picture, the energy centre on the right and behind the closest greenhouse. The purple floor area can be seen and the red measuring planes are visible also. Above the facility, the inverted measuring plane can be seen from this angle.



This is the same image as above, but with the calculation results indicated. Note that although the areas of light appear bright – it is because of the lack of light throughout the rest of the site making the areas appear bright against a dark background.



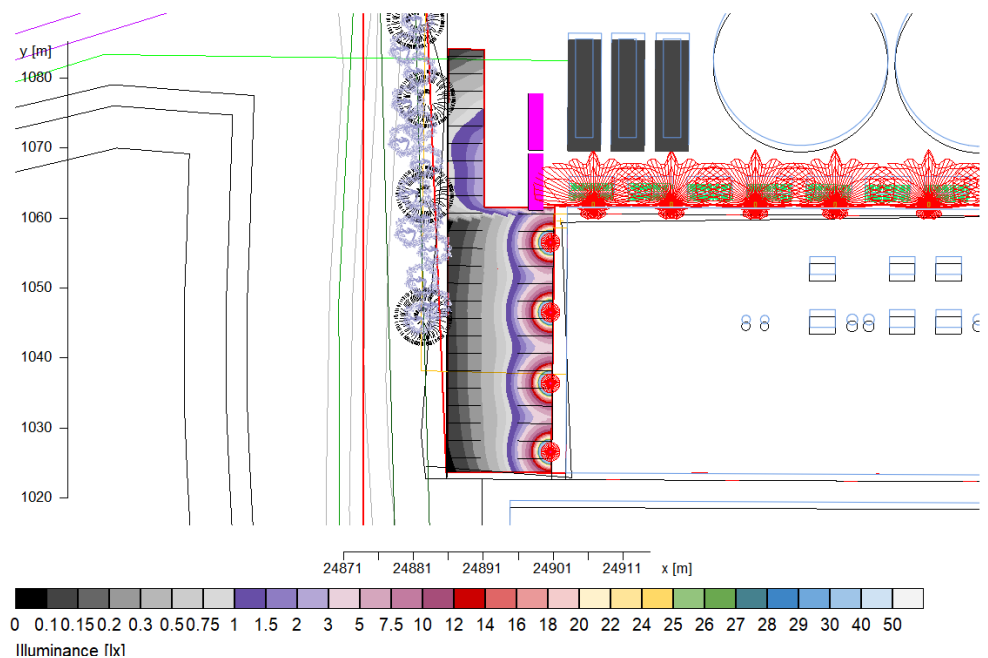
The further rendering below is the same image again, but this time the different light levels have been assigned a colour to represent the intensity – sort of akin to a heat map where the darker (grey and black) end of the colour spectrum represents little light and the other colours from the colder (blue) to the hotter (red) end of the spectrum representing the lux levels increasing. It should be noted that this represents a relative increase in light, from black to red as shown on the lux level legend at the bottom of the image.



Below is the layout of the Car Park West - showing the lighting distribution curves emanating from each luminaire. The wide wing type distribution is from the street

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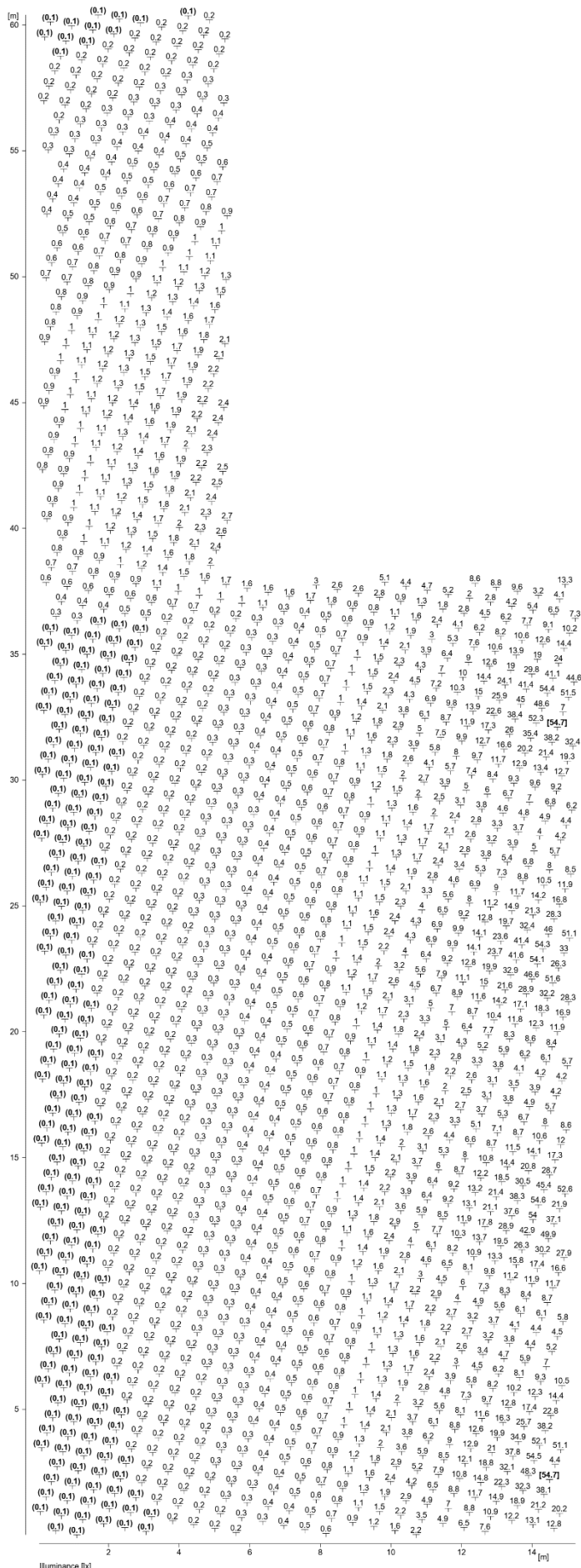
lighting lanterns fixed to the walls and the smaller distributions are from the ground mounted bollards. It can be seen that the car park area is not overlit and the light has minimal spillage outside this area.



The calculation results for the Car Park West are as follows:

Average illuminance 3.6 lux
Minimum illuminance 0.1 lux
Maximum illuminance 54.7 lux
Uniformity 0.02

And below is the table of results showing the specific lux levels at each point of calculation for the Car Park West:



6 ANALYSIS OF RESULTS

We understand that this installation is preferred to fall within the limits set by Category E2 in Table 1 of CIE 150 (2017) Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, 2nd Edition as reproduced in the Appendices below, as the installation is neither within a National Park or in an Area of Outstanding Natural Beauty.

In addition, it is understood that there are no observatories within 30km of the site and the only major observatory in close proximity is Jodrell Bank, approximately 65km distant, but that houses the Lovell Radio Telescope so is not relevant to this report.

The pertinent information from Table 1 is also shown here:

Vertical Illuminance on Properties	Pre-Curfew 5 lux (maximum) Post-Curfew 1 lux (maximum)
Luminous Intensity of luminaires	Pre-Curfew 0.57 x distance to viewer to 10 x distance to viewer) cd (maximum) Post-Curfew 0.29 x distance to viewer to 5.1 x distance to viewer) cd (maximum)
SkyGlow	ULR 2.5% (maximum)
Upward Flux Ratio	UFR 6% (maximum)
Building Luminance (average)	Pre and Post-Curfew 5cd/m2 (maximum)
Light trespass into Windows	Not applicable here

From the results provided by the software, the following can be determined:

Vertical Illuminance on Properties

There are no adjacent or nearby properties upon which the light could be trespassing, therefore this requirement can be considered to have been met.

Luminous Intensity of Luminaires

The Luminaire Luminous Intensity applies to the light source in the potentially obtrusive direction, outside of the area being lit. This is not applicable in this installation, as the luminaires are parallel to the floor.

SkyGlow

Upward Light Ratio is the maximum permitted percentage of luminaire flux for the total installation that goes directly into the sky. In this case, the luminaires selected have a ULOR [Upward Light Output Ratio] of 0%, so the SkyGlow element is also compliant.

Upward Flux Ratio

Upward Flux Ratio is an extension over Skyglow in that it also incorporates reflected light and is the maximum permitted percentage of luminaire flux for the total installation that goes directly into the sky. In this case, the luminaires selected have a ULOR of 0%. In order to demonstrate how much light is therefore directly and indirectly radiated above the installation, the following calculation is undertaken.

To calculate the UFR, we have used the equation given below as acquired from CIE 150 Section 6.4.3. We have also referred to Annex D and E of that document.

$$R_{UF} = \frac{\bar{E}_i}{\bar{E}_m} \left[1 + \frac{R_{ULO,\alpha}}{\rho_1 \cdot u} + \frac{\rho_2}{\rho_1} \left(\frac{R_{DLO,\alpha} - u}{u} \right) \right]$$

where:

R_{UF} = Upward Flux Ratio

$\bar{E}_i$ = Average Initial illuminance for the designed lighting installation

$\bar{E}_m$ = Average maintained illuminance on the area being lit

$R_{ULO,\alpha}$ = Upward light output ratio for the luminaires

$R_{DLO,\alpha}$ = Downward light output ratio for the luminaires

u = Utilisation factor of the installation

ρ_1 = Average ground reflectance

ρ_2 = Average reflectance of surrounding area

The utilisation factor can be calculated from the equation given in Annex D of CIE 150

$$u = \frac{\bar{E}'_m \cdot A_r}{f_m \cdot \Phi_{la}} = \frac{\bar{E}_i \cdot A_r}{\Phi_{la}}$$

where:

Φ_{la} = Assigned luminous flux of all involved lamps = 125,900 (from the software)

A_r = Area of the reference surface = 15,630m² (measured from CAD drawing)

$\bar{E}_i$ = Average Initial illuminance for the designed lighting installation = 4.1 lux

f_m = Maintenance factor = 0.8

$$u = (4.1 \times 15630)/125900 = 0.509$$

The following values have been inputted into the calculation to determine the UFR:

$$\bar{E}_i = 4.1 \text{ lux}$$

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$$E_m = 4.1 \text{ lux}$$

$$R_{ULO,a} = 0\% \text{ (as an average)}$$

$$R_{DLO,a} = 100\% \text{ (as an average)}$$

$$U = 0.509$$

$$\rho_1 = 0.15 \text{ (dark stone, closest equivalent to tarmac as taken from Annex E of CIE 150)}$$

$$\rho_2 = 0.3 \text{ (brown brick surrounding surfaces, as taken from Annex E of CIE 150)}$$

$$R_{UF} = 4.1/4.1(1+(0/(0.15 \times 0.509)))+(0.3/0.15(100^{-0.509}/0.509))$$

$$R_{UF} = 1(1+(0/0.076)+(2(0.096/0.509))$$

$$R_{UF} = 1(1+0+(2(0.189))$$

$$R_{UF} = 1(1+0.377)$$

$$R_{UF} = 1.377$$

This can be seen to be less than the required 6% maximum. This lack of obtrusive light can also be seen by examining the measuring plane for Light Spillage as previously detailed in this report.

Building Luminance (average)

Again, this is irrelevant here as the building is not, per se, illuminated. Obviously, there is some spillage onto the façade from the car park lighting, but this is a very small part of the overall non-illuminated façade, as previously detailed.

Light Trespass

The Light Trespass into Windows is not applicable here as there is no living accommodation in the immediate vicinity.

7 COMPARISON WITH CIBSE GUIDANCE AND BSEN 12464

As a reference, BSEN 12464 Part 2 is the standard that focuses on the recommendations for outdoor work places that are used at night and includes important recommendations on how obtrusive light can be limited, to keep the night sky free of light pollution

BSEN 12464-2 recommends 10 lux average illuminance in areas for medium traffic and slow-moving vehicles and 5 lux for pedestrian only areas, both with a uniformity of 0.25. The results here are below the recommended values, but this is considered sufficient in this instance for an installation that is trying to achieve a low light level and mitigate any impact on the local environment due to the installed lighting.

It would be necessary to ensure all vehicles only undertake movements with headlights on and it would be prudent to ensure that any large vehicles utilise a banksman or similar for safety.

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The calculation results for the East Car Park are as follows:

Average illuminance	7.6 lux
Minimum illuminance	0.0 lux
Maximum illuminance	37.2 lux
Uniformity	1:400

The calculation results for the West Car Park are as follows:

Average illuminance	3.6 lux
Minimum illuminance	0.1 lux
Maximum illuminance	54.7 lux
Uniformity	0.02

The calculation results for the Hardstanding are as follows:

Average illuminance	4.1 lux
Minimum illuminance	0.0 lux
Maximum illuminance	35.1 lux
Uniformity	0.0

8 CONCLUSIONS

With reference to CIE 150 (2017) Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, 2nd Edition, it can be seen that this installation is compliant.

With reference to the guidance within the Bat Conservation Trust's Designing for Biodiversity (2017), 2nd Edition, the lights are emitting primarily around 550nm wavelength mark with no UV components, all light is cut-off at the horizontal and the lighting fittings are mounted to provide excellent glare and distribution controls. In addition, the control system will further mitigate the impact on bat feeding habits and commuting routes. The installation can therefore be said to be as aligned with the guidance as possible, whilst still maintaining a low level of safety lighting to the area.

It can also be seen that the incidental light falling outside of the hardstanding area is minimal.

The below image is a representation of the bat foraging and commuting that were recorded as part of the surveys undertaken by the Environmental Consultants in order to provide the Ecology Report.

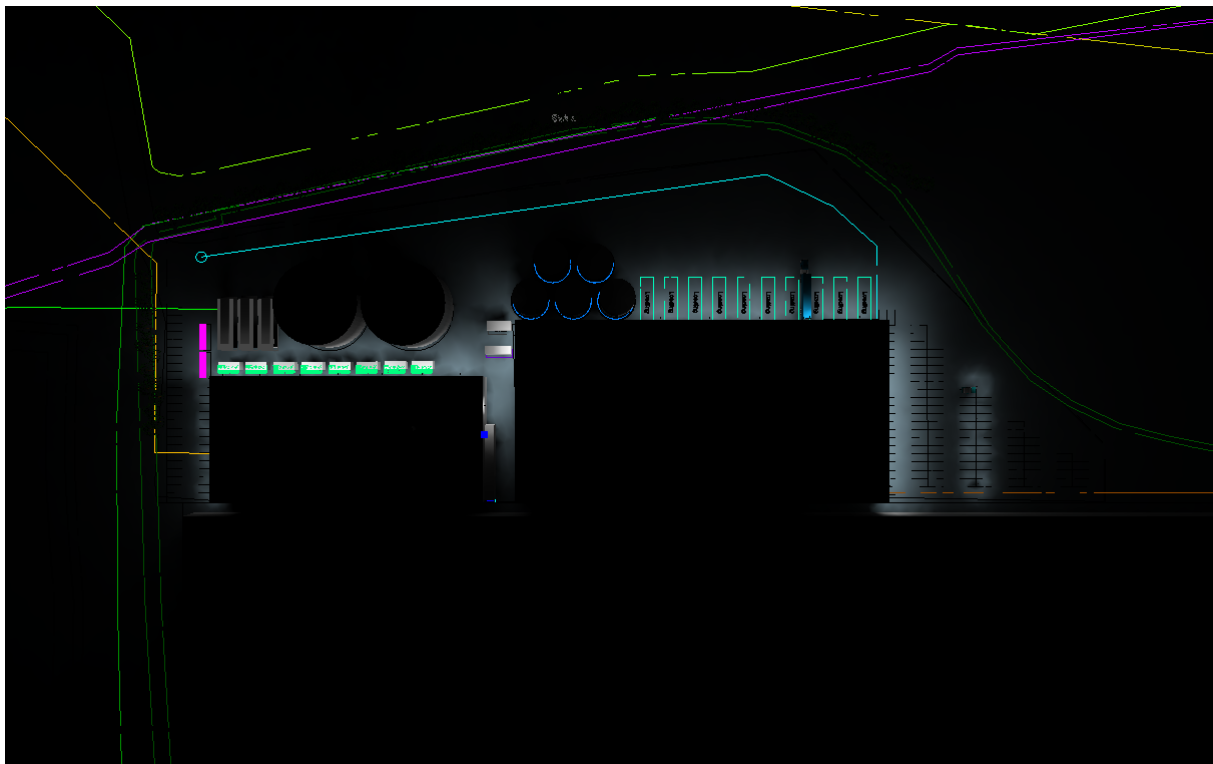
The Northern part of the site is closest to where the hardstanding and car parks are located and this is where the majority of the findings were made, along the river/woodland edge.



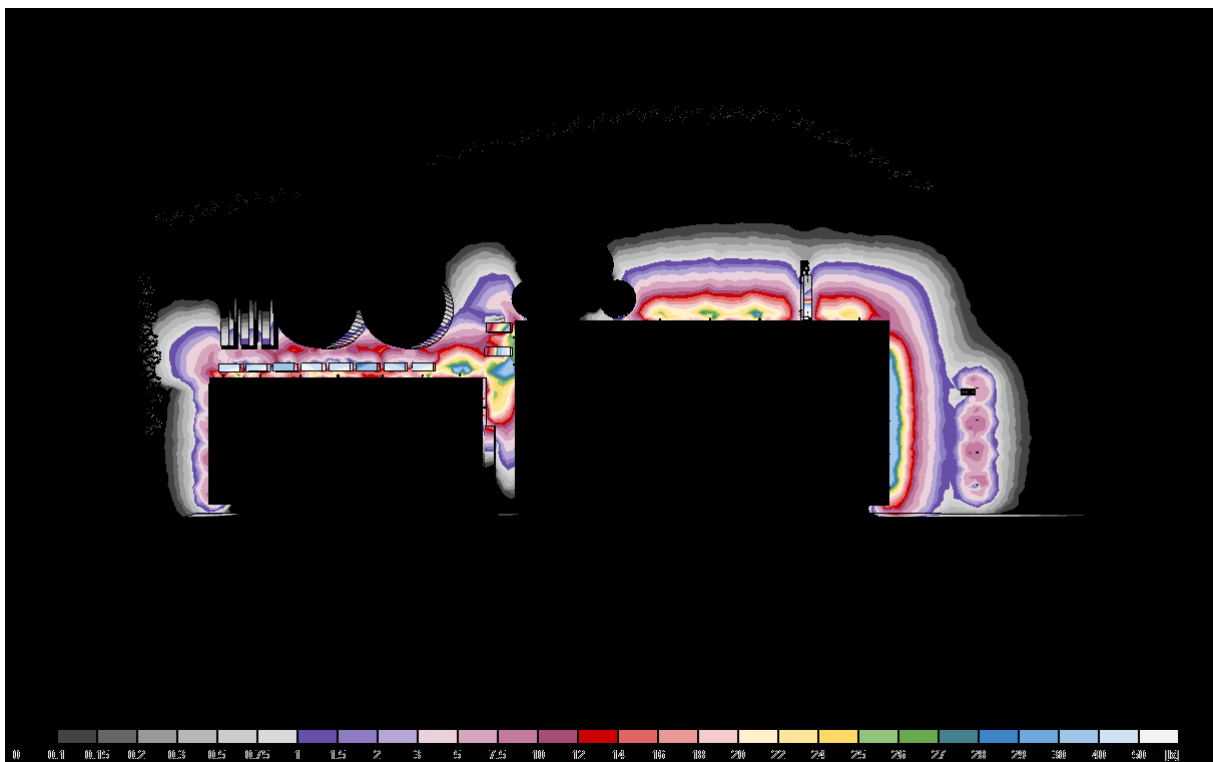
Below is a close up of the area where the hardstanding is to be located:



The following images are from the lighting design software and show the extent of light overspill, which is minimal.



Again, the same image but with the lux levels indicated.



Again, it can be seen that the proposed lighting will not interfere with the areas that bats have been noted.

With reference to CIBSE guidance and BSEN 12464 Part 2 the installation does not quite comply as the overall lux level is too low as is the uniformity. However, the intention for this installation is that a low level of light is provided purely for safety and higher levels would impact negatively on the surrounding environment.

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The expected maximum hours of illumination, given that this is primarily lighting of the car park and associated building areas for staff parking, will be as follows:

Summer 20:30 – 22:00

Winter 06:00 - 09:00 and 16:00 – 22:00

It should be reiterated that the lighting design has not yet been fully detailed and the fittings and controls indicated in this report are representative of the intention for the building installation at this stage.

9 APPENDICES

Appendix A – Site Layout Plan

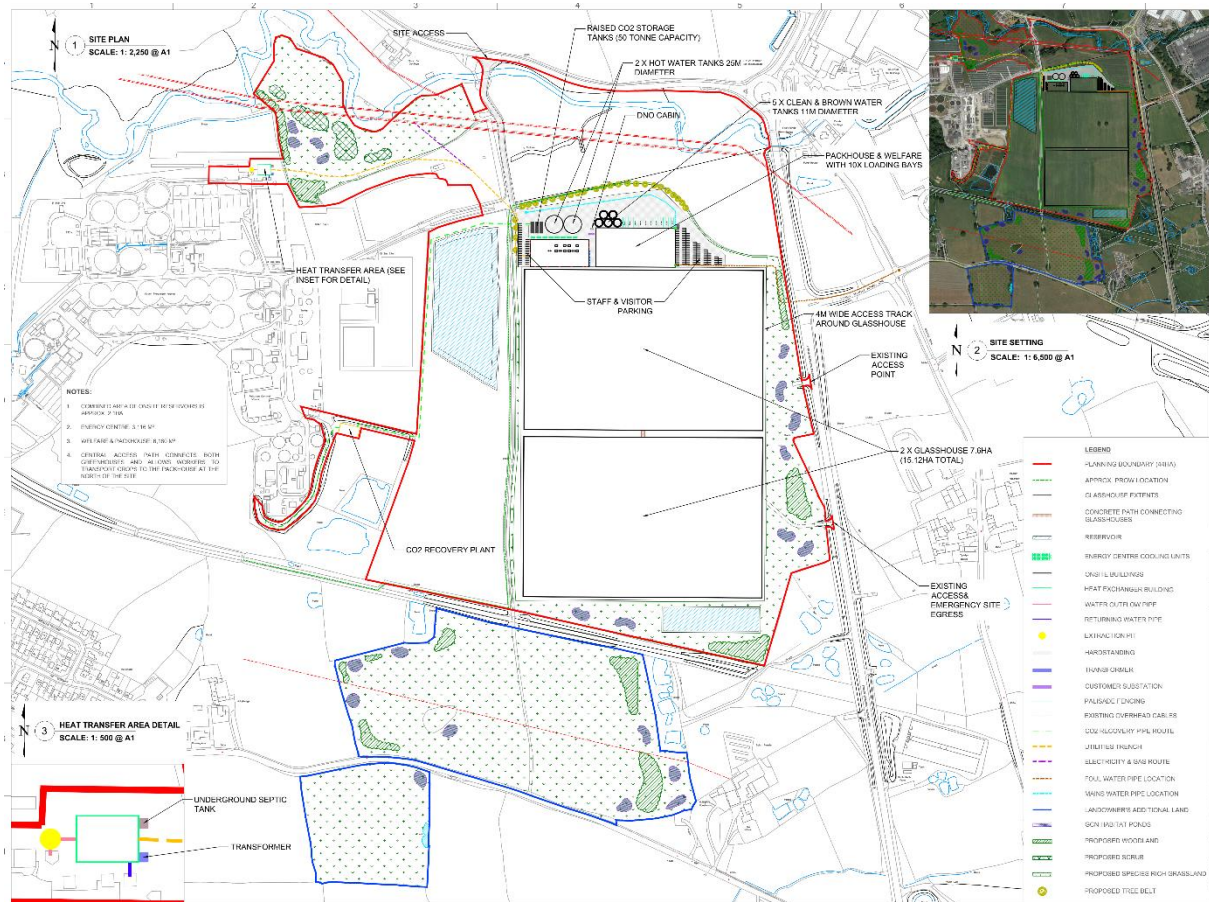
Appendix B – CIE 150 (2017) Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, 2nd Edition

Appendix C – Typical Combined Blackout and Light Pollution Screens to be used on the Project

Appendix D – Description of Typical Glasshouse Control Systems

Appendix E – Extract from the Bat Conservation Trust's Designing for Biodiversity (2017), 2nd Edition

9.1 APPENDIX A – SITE LAYOUT PLAN



9.2 APPENDIX B – CIE 150 (2017) GUIDE ON THE LIMITATION OF THE EFFECTS OF OBTRUSIVE LIGHT FROM OUTDOOR LIGHTING INSTALLATIONS, 2ND EDITION

3.6.4 Basis for differentiation of limits according to area type

The limits given in 3.6.5 are differentiated according to the environmental zone. The differentiation takes account of the ambient brightness of the environment to be experienced. The environmental zones are defined in Table 1.

Table 1 – Environmental lighting zones

Zone	Lighting Environment	Examples
E0	Intrinsically dark	UNESCO Starlight Reserves, IDA Dark Sky Parks, Major optical observatories
E1	Dark	Relatively uninhabited rural areas
E2	Low district brightness	Sparsely inhabited rural areas
E3	Medium district brightness	Well inhabited rural and urban settlements
E4	High district brightness	Town and city centres and other commercial areas
NOTE Regardless of the level of urban development, the recommendations for Environmental Zone 1 or 0, should be followed for all locations within 100 km of a major optical astronomy observatory. Regardless of the level of urban development, the recommendations for Environmental Zone 2 (or better) should be followed for locations within 30 km of an operating urban optical astronomy observatory, and for locations between 100 km and 300 km from a major optical astronomy observatory.		

3.6.5.1 Limitation of illumination on surrounding properties (light intrusion)

Table 2 shows maximum values of vertical illuminance on properties. Limits apply to nearby dwellings, or potential dwellings, more specifically to their relevant surfaces or parts of surfaces, especially where windows are. The values consider the summation of all lighting installations.

Table 2 – Maximum values of vertical illuminance on properties

Light Technical Parameter	Application Conditions	Environmental Zones				
		E0	E1	E2	E3	E4
Illuminance in vertical plane (E_v)	Pre-curfew	n/a	2 lx	5 lx	10 lx	25 lx
	Post-curfew	n/a	< 0,1 lx*	1 lx	2 lx	5 lx
* If the installation is for public (road) lighting then this value may be up to 1 lx.						

Table 3 – Maximum values for luminous intensity of luminaires in designated directions

Light Technical Parameter	Application Conditions	Luminaire group (projected area A_p in m^2)				
		$0 < A_p \leq 0,002$	$0,002 < A_p \leq 0,01$	$0,01 < A_p \leq 0,03$	$0,03 < A_p \leq 0,13$	$0,13 < A_p \leq 0,50$
Maximum luminous intensity emitted by luminaire (I in cd)	Environmental Zone E0 Pre-curfew: Post-curfew:	0 0	0 0	0 0	0 0	0 0
	Environmental Zone E1 Pre-curfew: Post-curfew:	$0,29 \cdot d$ 0	$0,63 \cdot d$ 0	$1,3 \cdot d$ 0	$2,5 \cdot d$ 0	$5,1 \cdot d$ 0
	Environmental Zone E2 Pre-curfew: Post-curfew:	$0,57 \cdot d$ $0,29 \cdot d$	$1,3 \cdot d$ $0,63 \cdot d$	$2,5 \cdot d$ $1,3 \cdot d$	$5,0 \cdot d$ $2,5 \cdot d$	$10 \cdot d$ $5,1 \cdot d$
	Environmental Zone E3 Pre-curfew: Post-curfew:	$0,86 \cdot d$ $0,29 \cdot d$	$1,9 \cdot d$ $0,63 \cdot d$	$3,8 \cdot d$ $1,3 \cdot d$	$7,5 \cdot d$ $2,5 \cdot d$	$15 \cdot d$ $5,1 \cdot d$
	Environmental Zone E4 Pre-curfew: Post-curfew:	$1,4 \cdot d$ $0,29 \cdot d$	$3,1 \cdot d$ $0,63 \cdot d$	$6,3 \cdot d$ $1,3 \cdot d$	$13 \cdot d$ $2,5 \cdot d$	$26 \cdot d$ $5,1 \cdot d$
	NOTE 1 d is the distance between the observer and the glare source in metres.					
	NOTE 2 A luminous intensity of 0 cd can only be realized by a luminaire with a complete cut-off in the designated directions.					
	NOTE 3 For further information, please refer to Annex C.					

Table 4 – Maximum values of threshold increment and veiling luminance from non-road lighting installation

Light Technical Parameter	Road Classification ¹			
	No road lighting	M6 / M5	M4/ M3	M2 / M1
Veiling luminance ² (L_v)	0,037 cd/m ²	0,23 cd/m ²	0,40 cd/m ²	0,84 cd/m ²
Threshold increment	15 % based on adaptation luminance of 0,1 cd/m ²	15 % based on adaptation luminance of 1 cd/m ²	15 % based on adaptation luminance of 2 cd/m ²	15 % based on adaptation luminance of 5 cd/m ²
¹ Road Classifications as given in CIE 115:2010 (CIE, 2010).				
² The veiling luminance values specified in this table are based on a permissible TI value of 15 %.				

Table 5 – Maximum values of upward light ratio of luminaires

Light Technical Parameter	Environmental Zones				
	E0	E1	E2	E3	E4
Upward light ratio (ULR) / %	0	0	2,5	5	15

Table 6 – Maximum values of upward flux ratio of installation (of four or more luminaires)

Light Technical Parameter	Type of Installation	Environmental Zones				
		E0	E1	E2	E3	E4
Upward flux ratio (UFR) / %	Road	n/a	2	5	8	12
	Amenity	n/a	n/a	6	12	35
	Sports	n/a	n/a	2	6	15

Table 7 – Maximum permitted values of average surface luminance

Light Technical Parameter	Application Conditions	Environmental Zones				
		E0	E1	E2	E3	E4
Building Facade Luminance (L_b)	Taken as the product of the design average illuminance and reflectance divided by π .	< 0,1 cd/m ²	< 0,1 cd/m ²	5 cd/m ²	10 cd/m ²	25 cd/m ²
Sign Luminance (L_s)	Taken as the product of the design average illuminance and reflectance divided by π , or for self-luminous signs, its average luminance.	< 0,1 cd/m ²	50 cd/m ²	400 cd/m ²	800 cd/m ²	1 000 cd/m ²
NOTE The values apply to both pre- and post-curfew, except that in Zones 0 and 1 the values shall be zero post-curfew. The values for signs do not apply to signs for traffic control purposes.						

9.3 APPENDIX C – TYPICAL COMBINED BLACKOUT AND LIGHT POLLUTION SCREENS TO BE USED ON THE PROJECT

Svensson Obscura 9950 FR W



OBSCURA 9950 FR W

Product information

Main Function	From light restriction to total blackout
System	Sliding, Hanging
Material composition	100% Polyester
Pattern	Plastic full
Flame retardant	Yes
Warranty	Warranty five (5) years under all types of greenhouse covering, see Svensson's limited warranty for all terms, conditions, and exclusions in writing.

Properties	Value	Unit	Test methods
Weight	88	g/m ²	
Width of strips	4	mm	
Shading level in direct light, PAR**	99	%	Integrated sphere
Shading level in diffused light, PAR**	99	%	Integrated sphere
Energy saving	50	%	Svensson method

* Width 50 mm

** PAR = 400 - 700 nm, accuracy +/- 1%

*** UV-light = 300 - 400 nm

This product image is for illustrative purposes only and may vary in appearance and design from the delivered product. Although the information in this data sheet has been composed with care, Svensson does not accept any liability in respect of its accuracy. Further information concerning the product and its installation may be obtained from Svensson and its authorized distributors. Svensson's products and name are protected by patent and other intellectual property rights. Products marked FR are flame retardant. No other products delivered by Svensson are flame retardant. AB Ludvig Svensson is an ISO 14001/90001 certified company.

9.4 APPENDIX D – DESCRIPTION OF TYPICAL GLASSHOUSE CONTROL SYSTEMS

Types & Control of Glasshouse Light Pollution Screens

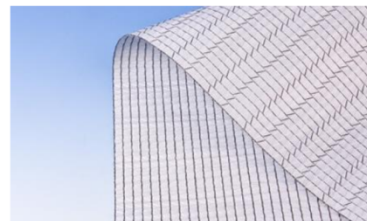
Light pollution and/or blackout screens are often used in a combination of horizontal and vertical screening, especially when growing crops using supplementary lighting.

It is now standard practice for greenhouse proprietors and site managers to meet increasing regulatory obligations on light emissions, the use of light pollution screens ensure minimal light emission and depending on the type of screen cloth, emission rates of less than 0.5% are achievable.

Through the use of light pollution screens, the light intensity of the supplementary lighting can be retained within the greenhouse. Furthermore, the light pollution screens open structure, in combination with good ventilation, helps control moisture and warmth.

With a light reduction level of over 99.9%, blackout screens are very suitable for light sensitive crops and short-day plants such as chrysanthemums. Additionally, by choosing a blackout screen with an aluminium top layer, energy savings can go up to 70%.

Typical horizontal light pollution screen material is a fire-retardant cloth with 50% energy saving properties and 99% shade – see adjacent image: -



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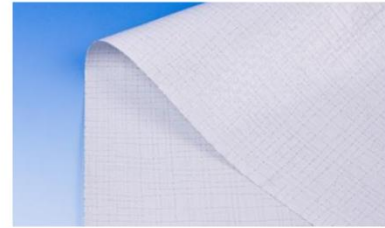
CambridgeHOK is a trading name of Cambridge Glasshouse Company Ltd. Registered in England no. 4266884



Typical horizontal blackout (light pollution screen) material is a fire-retardant cloth with 70% energy saving properties and 99.9% shade – see adjacent image: -



Typical vertical perimeter (light pollution) rolling screens material is a white fabric giving 70% energy saving and 100% shading. It is also a fire-retardant material, see adjacent image: -



To comply with local planning regulations and legislation, the control and management of the above illustrated light pollution screen systems and associated supplementary lighting systems must be via a (HMS) Horticultural Management System.

The typical HMS is a purpose built horticultural environmental computer system specifically designed for the control of all installed and related greenhouse equipment such as heating, ventilation, supplementary lighting, screen systems and irrigation.

HMS control of all modern light pollution screens is based on (astronomic) time i.e. sunrise (screen open) and sunset (screen closed). These HMS time controls are very accurate and precise being based on the greenhouse polar coordinates.

In addition, the (standard) HMS supplementary lighting controls will also include an electrical interlock/proving switch mechanism which physically prevents the supplementary lighting system from being switched on if the light pollution screens are open during sunset & sunrise.

9.5 APPENDIX E – EXTRACT FROM THE BAT CONSERVATION TRUST'S DESIGNING FOR BIODIVERSITY (2017), 2ND EDITION

The below extract from the Guide highlights an exemplar scheme for reference.

The Warren Footpath runs along the Thames River between Richmond and Twickenham in south London. Richmond upon Thames Council needed to replace the existing low sodium lighting but wanted a solution that would reduce the impact on the bat species that use the river for foraging. The council worked with the Thames Landscape Strategy, the Bat Conservation Trust and Philips Lighting to deliver an intelligent lighting innovation that could deliver bright white LED light, which would ensure that residents feel safe and secure when using the footpath but would not flood the area with too much light and disturb the nocturnal wildlife living in the area.

THE SOLUTION

The centrepiece of the lighting scheme introduced by Philips was LumiMotion, an LED outdoor lighting technology detector, control device and communicator all in one. By intelligently sensing activity around it, LumiMotion adjusts the lighting to a maximum level when there is activity and to extremely low levels when there is no activity – when someone approaches, light levels will rise from 20% to 100%, or to any level in between those percentages as required. The system is also programmed to recognise and communicate to neighbouring street lighting fittings via radio, so that presence and absence is relayed. Thus, a 'carpet of light' is created as a person walks along the stretch of path where the system has been installed, guiding them along.

The system incorporates a sensor and camera within the fitting which is able to detect activity within a 20–30 m diameter circle – minus the area that is in shadow of the mast. The video detection is based on pixel changes instead of images. The system can be tailored to take into account differing street widths, light levels and even obstacles such as trees or construction in streets.

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